New Hampshire Geological Survey's Annual

Geologic Mapping Workshop 2016

Wednesday April 6, 2016
9:00 AM – 12:30 PM*
NHDES Auditorium, NHDES, Concord
29 Hazen Drive, Concord, New Hampshire 03302-0095

Public Session Agenda

8:30 – 9:00 AM **Coffee and Poster Session in Auditorium Anteroom****

9:00 – 9:10 **Welcome and NHGS Program Update**
Rick Chormann, NH State Geologist

Guest speakers:

9:10 – 9:40 **Larry G. Ward, Zachary S. McAvoy, Maxlimer Vallee-Anziani, Kelly Nifong, Erin Nagel and Paul Johnson, UNH Center for Coastal and Ocean Mapping/Joint Hydrographic Center** – ***"Development of Surficial Geology Maps of the New Hampshire and Vicinity Continental Shelf."***

The New Hampshire continental shelf is highly complex and includes extensive bedrock outcrops, remnant glacial deposits, marine formed features, and muddy basins. Many of the depositional features are glacial in origin, but are significantly modified by marine processes as sea level fluctuated since the end of the last major glaciation. Some of the apparent glacial deposits are eroded leaving very coarse lag deposits while supplying sand which likely developed wave formed features. As a result the New Hampshire continental shelf morphologic features and sediments are highly diverse and vary over short distances. Fortunately, relatively recent high resolution multibeam echo sounder (MBES) bathymetric and backscatter surveys provide exceptional detail of the New Hampshire and vicinity seafloor. As a first step in mapping the complex seafloor, the MBES bathymetry and backscatter was synthesized by the University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center and is available online. The synthesis of the MBES bathymetry and backscatter, coupled with an extensive archived database consisting of subbottom seismics, bottom sediment grain size data and vibracores, is being used to develop new surficial geology maps (with support from the Bureau of Ocean Energy Management). The mapping effort is focusing on morphologic features (geoforms), classification of the grain size of surficial sediment, and description of selected sand and gravel deposits. The development of the surficial sediment maps is based on the Coastal and Marine Ecological Classification Standard (CMECS). The new surficial geology maps are in draft form and need extensive verification, but represent a major advance in our efforts to understand and characterize the New Hampshire and vicinity continental shelf. In addition, some of these deposits may represent significant sand and gravel resources that have the potential for future use for beach nourishment and other efforts to build coastal resiliency.

9:40 – 10:00 **Jim Degnan, US Geological Survey** – ***"Preparing a Preliminary Fractured Bedrock Conceptual Model to Address Water Quality Concerns Using Existing Site and Regional Scale Information: Approaches and Case Studies".***

Groundwater flow in crystalline bedrock in New England is complex. A preliminary conceptual model combining regional- and site-scale information may provide considerable understanding of the system and guide additional investigations. Fracture patterns form a heterogeneous aquifer resulting in groundwater flow that varies with location, depth, and rock type. Fracture transmissivity has a range of several orders of magnitude. Low transmissivity fractures can function as reservoirs retaining and slowly releasing legacy contaminants. The travel time is also important to consider as groundwater chemistry evolves over time affecting the fate and transport of natural and anthropogenic contaminants. For example, nitrate can become degraded over long paths and travel times as oxygen is consumed in rock-water reactions but relatively persistent where oxygen is available. We advocate a coupled examination of aqueous chemistry and traditional aquifer and geologic mapping data to help identify low- and high-transmissivity fracture zones. Information from regional aquifer studies and geologic maps can help guide conceptual model development in areas without data and can constrain the boundaries of the hydrologic system. For example, overburden aquifer studies may have information describing the bedrock surface that can serve as criteria to help identify fracture zones. In addition, water table or potentiometric surfaces can be used to identify regional points of discharge or spatial patterns in pumping drawdown that may indicate where an underlying anisotropy has influenced flow directions. Case studies documenting the identification of potential high-transmissivity zones in the aquifer (preferential flowpaths) as well as low-permeability zones that may result in lingering contamination through back diffusion will be presented. A workflow involving an iterative process of interpretations based on regional understanding, data processing, and integration will be outlined. The relation between geologic features, contaminants, and geophysical methods will also be highlighted. Rigorous retrospective data analysis as the first step in a preliminary assessment, can save time, costs, and serve to focus subsequent efforts that will minimize duplication and maximize understanding.

10:00 – 10:20 **Greg Walsh, US Geological Survey** – ***"Status Report of Bedrock Geologic Mapping by the USGS in New Hampshire."***

This talk will present the results of ongoing mapping as part of the FEDMAP component of the USGS National Cooperative Geologic Mapping Program. Work is primarily focused in the Connecticut River Valley region in a four-quadrangle area around Littleton and an eight-quadrangle-area from Lebanon to Alstead. The discussion will focus on advances in our knowledge of the evolution of the Bronson Hill anticlinorium, insight gained about digital mapping procedures including implementation of the NCGMP09 data model, and new field tools for digital data acquisition.

10:20 – 10:40 **Break (Posters)**

Meghan Arpino, UNH Department of Earth Sciences – ***"Using high resolution topography and tracer studies to understand fluvial transport processes during low to moderate flows."***

Taylor Hodgdon, UNH Department of Earth Sciences – *"Developing a chronology for thinning of the Laurentide Ice Sheet in New Hampshire during the last deglaciation."*

Kaitlyn McPherran, UNH Department of Earth Sciences – "*Observations of seasonal changes and storm effects on a bedrock-influenced, paraglacial coastal system: New Hampshire*."

10:40 – 11:10 **Dykstra Eusden, Sarah Baker, and J. Cargill** – **Department of Geology, Bates College – *"Bedrock Geology of the Southern Half of the Jefferson 7.5' Quadrangle, New Hampshire."***

The purpose of this study was to produce an updated, detailed bedrock map of the southern half of the Jefferson NH 7.5' quadrangle at the scale 1:24,000 as a part of the USGS/NHGS STATEMAP program. This work builds upon the previous detailed mapping of the adjacent Mt Washington East and Mt. Dartmouth 7.5' quadrangles. This study area contains older Ordovician rocks of Jefferson Dome, one of the Oliverian gneiss domes of western New Hampshire, and younger Jurassic rocks of the Pliny Range Caldera Complex that cut the older rocks. From oldest to youngest, new mapping has identified the following units: 1) Ordovician hornblende gneiss (+/-amphibolite) transitioning to K-feldspar-rich orthogneiss with increasing proximity to the Pliny ring dikes; 2) Silurian (new age 430.6±2.6 Ma) syenite; 3) a Jurassic (?) basalt dike correlative to the Mill Brook Dike; and the following Pliny Complex rocks: 4) Jurassic diorite; 5) Jurassic porphyritic quartz monzodiorite; 6) Jurassic hornblende quartz syenite; 7) Jurassic quartz monzodiorite; 8) Jurassic pink biotite granite (new age 188.3±1.0 Ma) that is essentially coeval with; 9) Jurassic Conway granite (new age 187.3±1.1 Ma); and 10) a newly discovered Jurassic flow banded and spherulitic rhyolite (new age 184.9±2.3 Ma).

The syenite is not visibly deformed and cuts the strongly foliated Ordovician gneiss suggesting that either, some deformation in the Jefferson Dome may actually be older (Ordovician?) than previously thought, or, the syenite was rheologically strong enough to not develop a foliation and the deformation is still all Acadian. All of these units were in turn intruded by a series of near contemporaneous Jurassic caldera intrusive and extrusive rocks of the Pliny Range Caldera Complex. Three main phases of caldera development are recorded in the Pliny Complex. The first is the intrusion of cone sheets of diorite, porphyritic quartz monzonite, and hornblende quartz syenite. These developed synchronously with, or slightly after, the deflection of Oliverian Dome foliations into parallelism with the caldera margin and also the intrusion of high temperature hornblende veins. A major caldera-bounding fault (thrust, changing slip to normal?) is likely to have formed at this time to deflect the foliations. The second phase of caldera development is the intrusion of two more inward dipping cone sheets of sometimes commingling quartz monzodiorite and pink biotite granite, both without hornblende veins. These sheets may have intruded on the postulated fault and done so somewhat passively as during this second phase of caldera development the blocks of Ordovician gneisses and Silurian syenites were only slightly deflected, if at all. The last phase of caldera development is the intrusion of the Conway Granite as near circular stocks cross cutting all rocks and the extrusion or shallow intrusions of the newly discovered rhyolites.

The new rhyolites have both XRF chemistry and petrologic textures that closely match artifacts of the Jefferson Rhyolite, a stone used to make the characteristic fluted spear points used by Paleoindians 13,000-11,000 years ago and documented at numerous archaeological sites in the Northeast. This suggests that the rhyolite outcrops were likely sources for quarrying by the Paleoindians.

11:10 – 11:35 **Peter Thompson, University of New Hampshire (retired)** – ***"New Ideas on Structures in West-Central New Hampshire."***

This talk will present new ideas on structures in west-central New Hampshire. The Northey Hill "line" is a one to two km wide zone (NHZ) that extends from Northey Hill, where it offsets an antiform (Salmon Hole Brook and Garnet Hill synclines of Billings), SSW 80 km to the vicinity of Skitchewaug Mountain. The zone is characterized by steep, post-dome-stage foliation (for example the Sunday Mountain cleavage belt) and by lower metamorphic grade than rocks on either side. It lies east of and sub-parallel to the Mesozoic Ammonoosuc fault (AF).

In the Moosilauke 15' Quadrangle the NHZ apparently follows the western margin of the Devonian Haverhill pluton. Farther south it consists of a zone of highly attenuated and locally intercalated Bronson Hill stratigraphic units, between the eastern limit of the Piermont allochthon (Rangeley stratigraphic sequence) and the western margin of the Indian Pond pluton, west of the Bronson Hill arch (BHA). The west side of the zone apparently moved down, dropping the allochthonous rocks to the level of the Bronson Hill rocks. Farther south, the Cornish nappe, which lies under the Piermont rocks, also moved down relative to the BHA. Nappe-stage foliation around the Lebanon dome is drawn into parallelism with and overprinted by the steep NHZ foliation. East of the dome discrete faults within the NHZ sinistrally offset and truncate nappe- and dome-stage folds in the Clough-correlative Hardy Hill Quartzite.

The Garnet Hill syncline is re-interpreted as antiformal, opening downward toward the west rather than upward toward the east, with the overturned limb of the Cornish nappe above it. This suggests that the Cornish nappe is rooted east of the BHA. The Lebanon pluton lies within the Cornish nappe, and thus would seem to be allochthonous, perhaps rooted in the vicinity of the Wentworth dome. Minor folds on the eastern, lower limb of the Garnet Hill antiformal syncline (e.g. folds in the Clough Quartzite at Mt. Cube, Croydon Mountain) are only that, and not the Skitchewaug nappe as proposed by earlier geologists. The Cornish and Skitchewaug nappes may be one and the same structure.

The NHZ continues SSW between the dome-stage Meriden antiform and the BHA to connect with the anastomosing, SSW-striking Westminster West fault system (WWF) south of Skitchewaug Mountain in Vermont. The AF crosses these older faults obliquely, with little apparent offset, because all are nearly vertical. To confirm the correlation of the NHZ and 300 Ma WWF, Ar-Ar ages on micas from the NHZ foliation would be helpful. Together the older faults represent a 140+ km-long, relatively straight, steep fault system, which suggests that a deep-seated discontinuity was responsible. Perhaps the NHZ is the surface manifestation of deep-seated Gander basement jostling against Laurentian basement along the suture during the Northfieldian precursor to the Alleghanian orogeny. It likely was reactivated during the Mesozoic, when the AF also formed along a similar path. Published detrital zircon studies suggest that the suture at the present-day surface lies well to the west.

11:35– 11:55 **Woodrow Thompson, Maine Geological Survey (retired)** – ***"Surficial Geology of the Squam Mountains Quadrangle, Central New Hampshire"***

The Squam Mountains quadrangle is located on the boundary between New Hampshire's Lakes Region and the White Mountains. The Squam Lake basin occupies the SE quarter of the map area, with the long narrow Squam Mountains ridge lying just NW of the lake. These mountains are in turn bordered to the NW by the Beebe River valley and Sandwich Range. Till is the dominant surficial map unit over most of the quadrangle, and bedrock crops out extensively at high elevations. Wholesale glacial plucking of the Winnipesaukee Tonalite formed the Squam Lake basin, while more resistant Kinsman Granodiorite and various metasedimentary rocks underlie the Squam Range. Pit exposures in a sheltered gully just N of West Rattlesnake Mountain preserve thick disintegrated syenite (rottenstone) that formerly could be seen beneath fresh glacial till when studied by J. W. Goldthwait in the 1930s. Striations and fluted till ridges indicate flow of the Laurentide Ice Sheet to the SE or ESE over most of the quadrangle, with the notable exception of a late nearly eastward flow recorded at a multiple-striation locality on Long Island in Squam Lake. Glacial sand and gravel occurrences are limited to a few scattered ice-contact and outwash units, and one minor suspected glacial lake deposit. These sediments are poorly exposed in small inactive pits. The scarcity of stratified drift is attributed to the Squam and Sandwich Ranges being oriented transverse to ice flow. During glacial retreat, these mountains caused the thinning still-active ice sheet to the NW to become detached from remnant ice masses in the Squam Lake and Beebe River lowlands. Without a major ice tunnel (esker) system to convey sediment to the glacier margin, these masses simply melted down and left till deposits. Sand and gravel in the Beebe River valley is mostly either Holocene alluvium or coarse, poorly-sorted stream terrace gravel at elevations just above the modern flood plain.

11:55 – 12:10 **John Brooks and Dan Tinkham, Emery and Garrett Groundwater, Inc.** – ***"Surficial Geology of the Melvin Village 7.5' Quadrangle, New Hampshire."***

Mapping during 2015 delineated glaciofluvial and glaciolacustrine deposits graded to Glacial Lake New Durham (draining down the Cocheco River Basin) and early stages of Lake Winnipesaukee (draining to the Merrimack River Basin). LIDAR imagery was very helpful in highlighting ice-contact features and post-glacial fans at the base of the Ossipee Mountains.

12:10 – 12:20 **Greg Barker, NH Geological Survey** – ***"Surficial Geology of the Mt. Dartmouth 7.5' Quadrangle, New Hampshire."***

This talk will present results of the 2015 mapping of surficial geologic features of this quadrangle. The mapping continues work previously performed by W.B. Thompson (1:250,000 scale work) and 1:24000 scale mapping of neighboring quadrangles starting in the west, traversing through the south and to the northeast (Fowler and Hildreth). The majority of the features mapped relate to the deglaciation of the region with Holocene features related to current day fluvial systems. The Pleistocene deposits consist of two primary styles of deposition, either mass down-wasting derived tills and alluvial/colluvial fans or glaciolacustrine/glaciofluvial sequences. Till covered peaks dominate the interior of the quadrangle. The northern and southern edges of the quadrangle feature glaciolacustrine-glaciofluvial systems, that are the modern day Israel and Ammonoosuc Rivers, respectively. There also is at least one, documented mass wasting event, the Owl's Head Landslide of 1885. LiDAR was available for only a small portion of the quadrangle and proved useful for identifying several morainal features in the southeast corner of the quadrangle. Were it not for these data, it is likely these features would have gone undocumented.

12:20 **Questions and closing remarks**
Rick Chormann, NH State Geologist

(Lunch available in the Café on the lower level.)

Private Working Session for NHGS Mappers in Room 213

1:15 – 3:15 Mapping contractor meeting for those who map for the NHGS under the STATEMAP program.

Directions to NH Department of Environmental Services
The main offices of DES (including the New Hampshire Geological Survey) are located at 29 Hazen Drive, Concord, NH.

From the South and West
Take I-93 north to Exit 14 turning right at the end of the exit ramp. At the fourth light (at top of the hill), turn left onto Hazen Drive. Turn left at sign for Health & Human Services. Visitor parking is available in front of building.

From the North
Take I-93 south to Exit 15E onto I-393. Take Exit 2 and turn left at end of exit ramp (East Side Drive). Stay to the right and turn right at light onto Hazen Drive. Turn right at sign for Health & Human Services. Visitor parking is available in front of building.

From the East
Take Route 4 west to Concord (Route 4 becomes I-393 in Concord). Take Exit 2 and turn left at end of exit ramp. Stay to the right and turn right at second light onto Hazen Drive. Turn right at sign for Health & Human Services. Visitor parking is available in front of building.

Note: If you have not already done so, please <u>respond by email if you plan to attend</u> so that we can anticipate the number of attendees. If you need further information on the program or **to R.S.V.P., please contact the NH Geological Survey at: <u>geology@des.nh.gov</u>**

Attendance at the entire public session part of the workshop qualifies for 3.5 CEU's

Please bring photographic identification (***e.g.*** **driver's license) in order to be admitted to the DES Building. Thank you.**

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* NHDES employees should confirm their attendance and schedule of the workshop with their supervisors.

** Posters will be on display until the end of the public session of the workshop.